Multi-Agent ML Stock Trading

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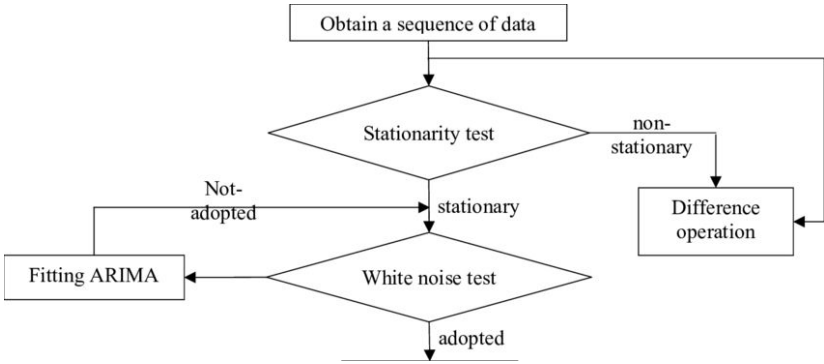
Purpose

- Sought to tackle a comparison of a variety of ML-based stock prediction approaches on a common dataset
- Involved training different profit-maximizing agents to respond to market changes, and finally, compare the results and efficacy of these agents
- Intended on building a Mixture of Experts control model on top of the successful agents to take advantage of the strengths of each type of model, but ran out of time (might be done by report submission)

Environment

- Framed around gymnasium library
- 24 OHLCV standardized stock datasets as the observation space
- Processes data to confirm uniform observations, then store in an array of dictionaries
- step() function takes in list of actions for each stock and returns percent change from open to close as reward
- Getter functions to return train and test datasets
- Inspired by AI4Finance's FinRL, Deep Q-Trading GitHub Repo - uses an ensemble of agents to prevent overfitting

ARIMA



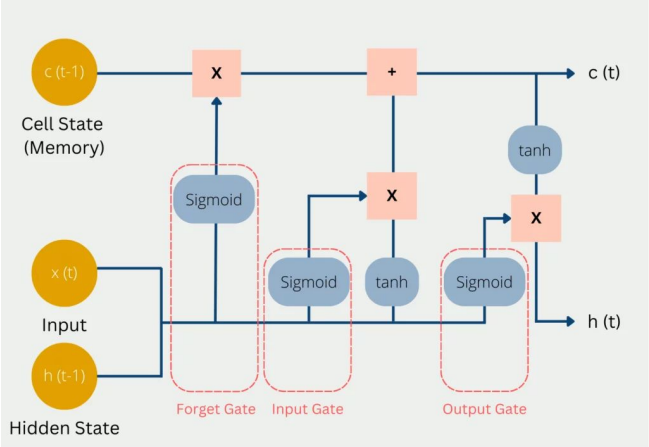
- Autoregressive Integrated Moving Average
- One ARIMA model for each stock
- Constructed using Statsmodels
- Needs to first ensure stationarity in time series using ADF test (Augmented Dickey Fuller)

Total Correct Bought: 85810, Total Bought: 305003, Precision (Buy only): 0.281341495

Total Correct Sold: 109425, Total Sold: 456810, Precision (Sell only): 0.23954160373

Correct: 195235, Total: 761813, Precision: 0.25627680283

LSTM



- Long Short Term Memory - a type of RNN
- One LSTM model for each stock
- LSTMs constructed using Keras
- Have a helper/wrapper class that controls all LSTM models, making buy/sell/hold decisions for each stock at each timestep
- Wrapper class works with environment to decide actions

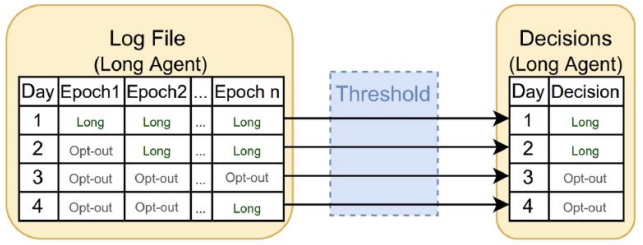
Total Correct Bought: 54666, Total Bought: 127472, Precision (Buy only): 0.4288471193673905

Total Correct Sold: 289636, Total Sold: 634341, Precision (Sell only): 0.4565935356535365

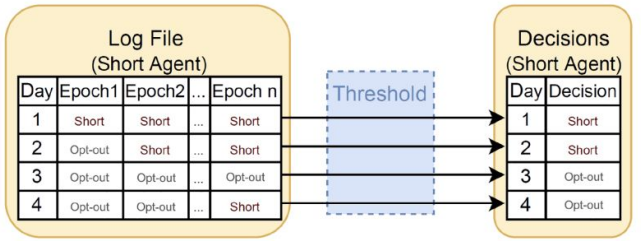
Correct: 344302, Total: 761813, Precision: 0.4519508068252970 4

Benchmark Agents

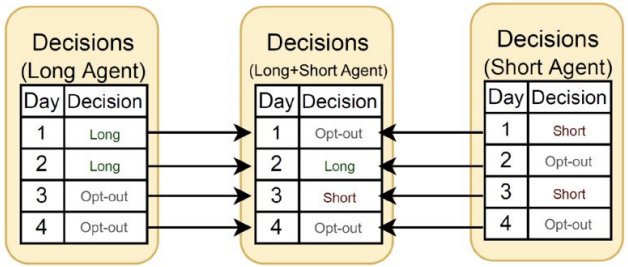
- Benchmark Agents, used to compare to more convoluted models
  - Random - Agent makes a random decision at each step
  - Heuristic - Agent makes a decision based on heuristic at each step
    - Two Heuristics Defined:
      - Heuristic 1: Buy if close price is higher than open price, sell otherwise
      - Heuristic 2: Buy if close price is higher than 50-day moving average, sell otherwise
  - Buy-and-Hold - Agent buys stocks and holds them for a long period of time
  - Long/Short Only Agent - Agent performs long (buying then selling before end of day) or short actions (selling the stock and then buying it again before the market closes), otherwise it can opt out
  - Long + Short - Agent combines Long/Short option and does one or the other depending on what each agent returns
- The Buy and Hold agent is the standard for comparing to other models
- The Benchmark agents are not included in the final submission
  - They were used instead as an internal litmus test in order to ensure we were on the right track



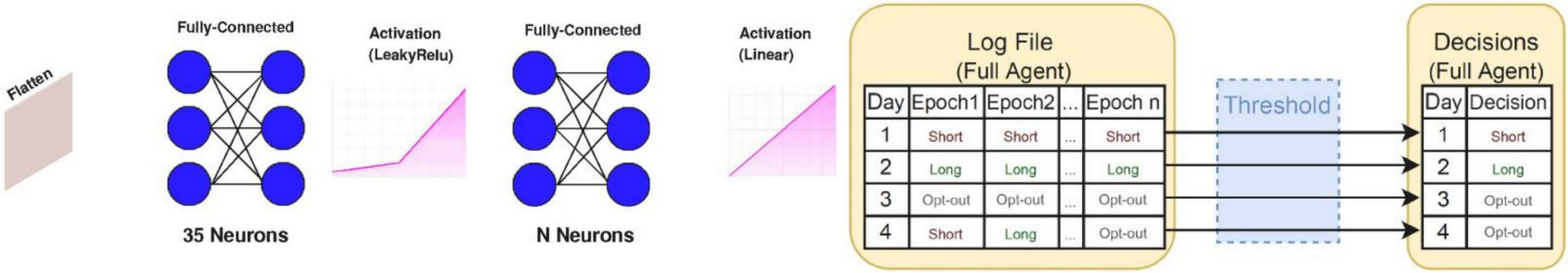
(a) `Only-Long` agent;



(b) `Only-Short` agent;



(c) `Long+Short` agent;

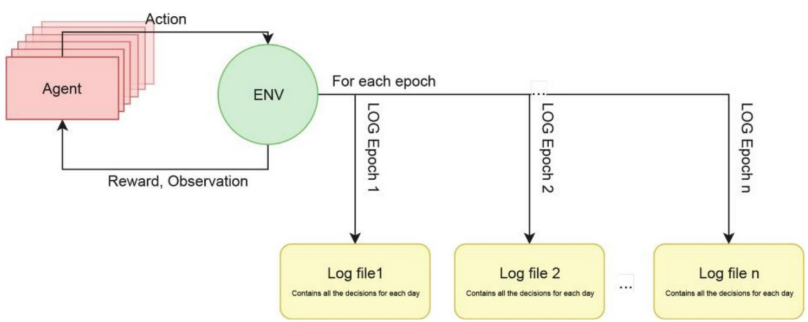


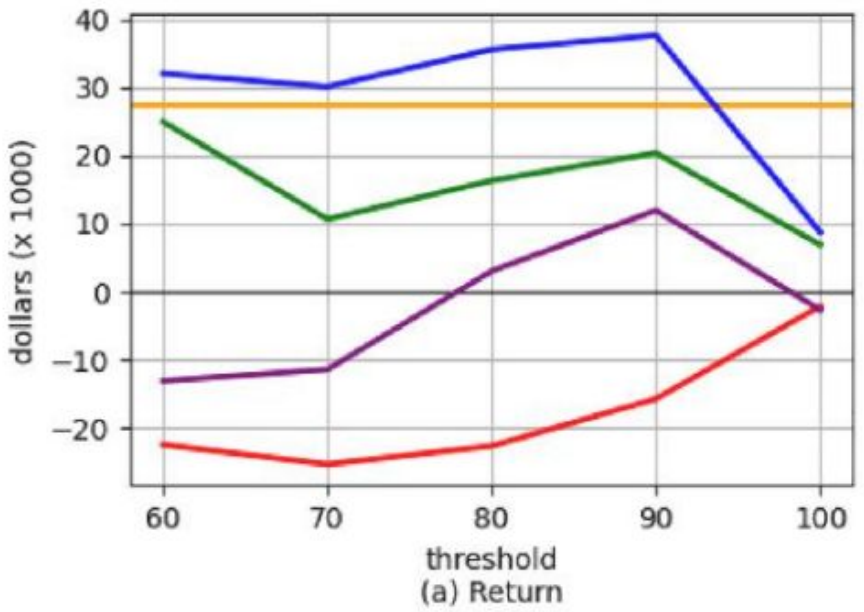
- DQN (Deep Q-Network) - a type of RL model
- Network of collaborative agents
  - Trained on different timescales to optimize long and short horizon outlooks

Total Correct Bought: 253880, Total Bought: 350906,
Precision (Buy only): 0.7235

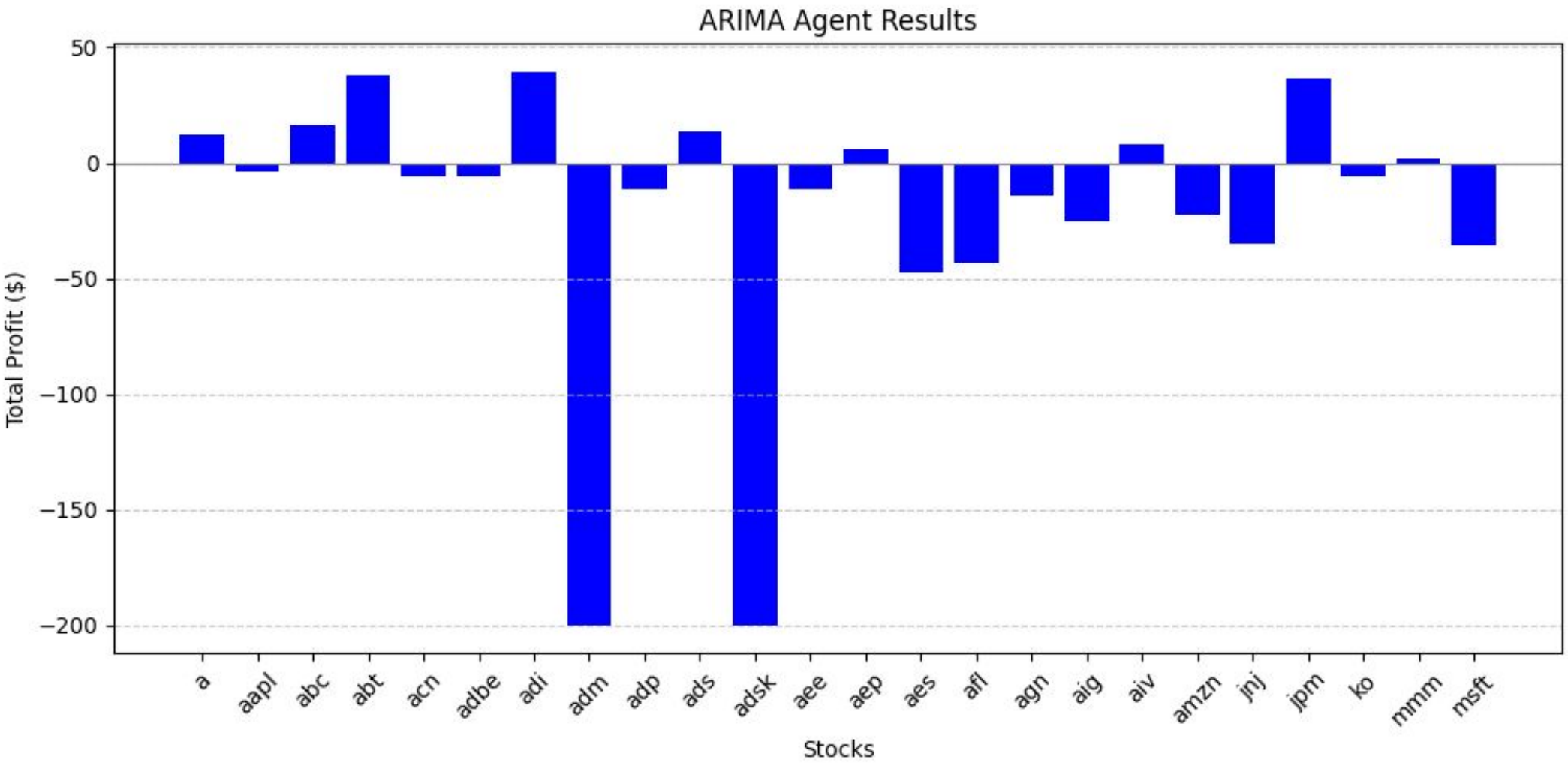
Total Correct Sold: 256981, Total Sold: 410907,
Precision (Sell only): 0.6254

Correct: 510861, Total: 761813,
Precision: 0.67058582618

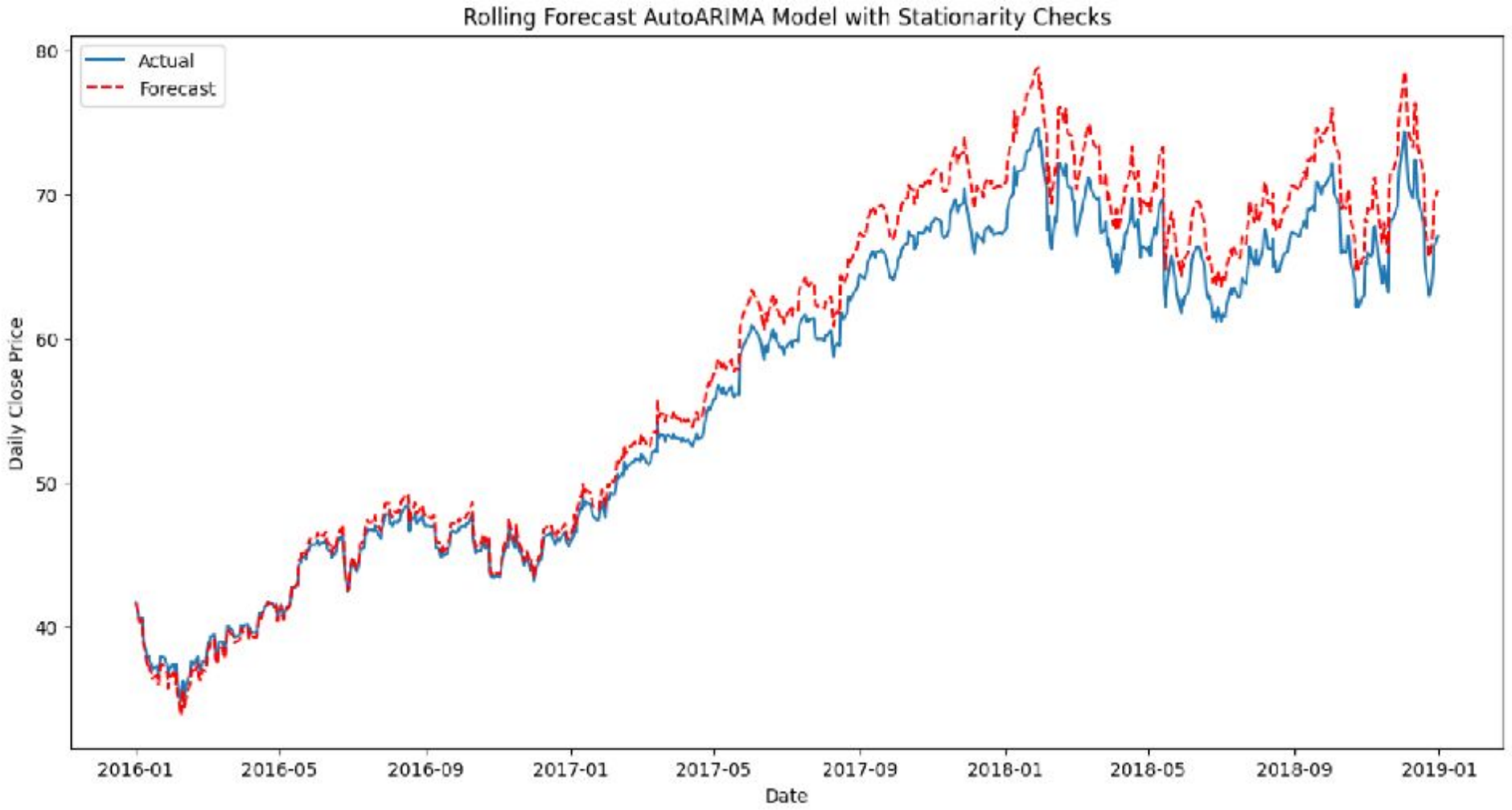




ARIMA Initial Results

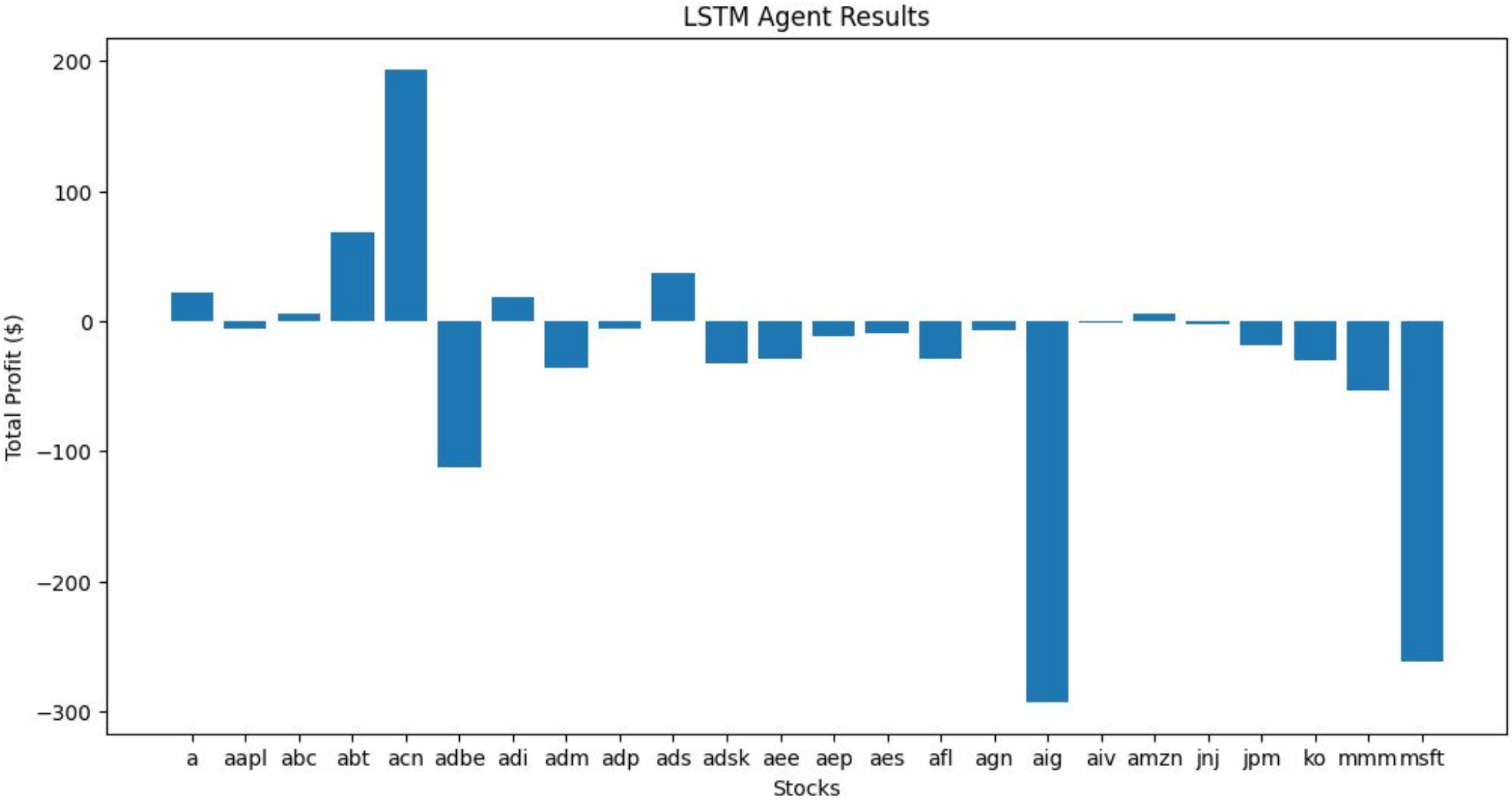


ARIMA Results after Rolling Forecast

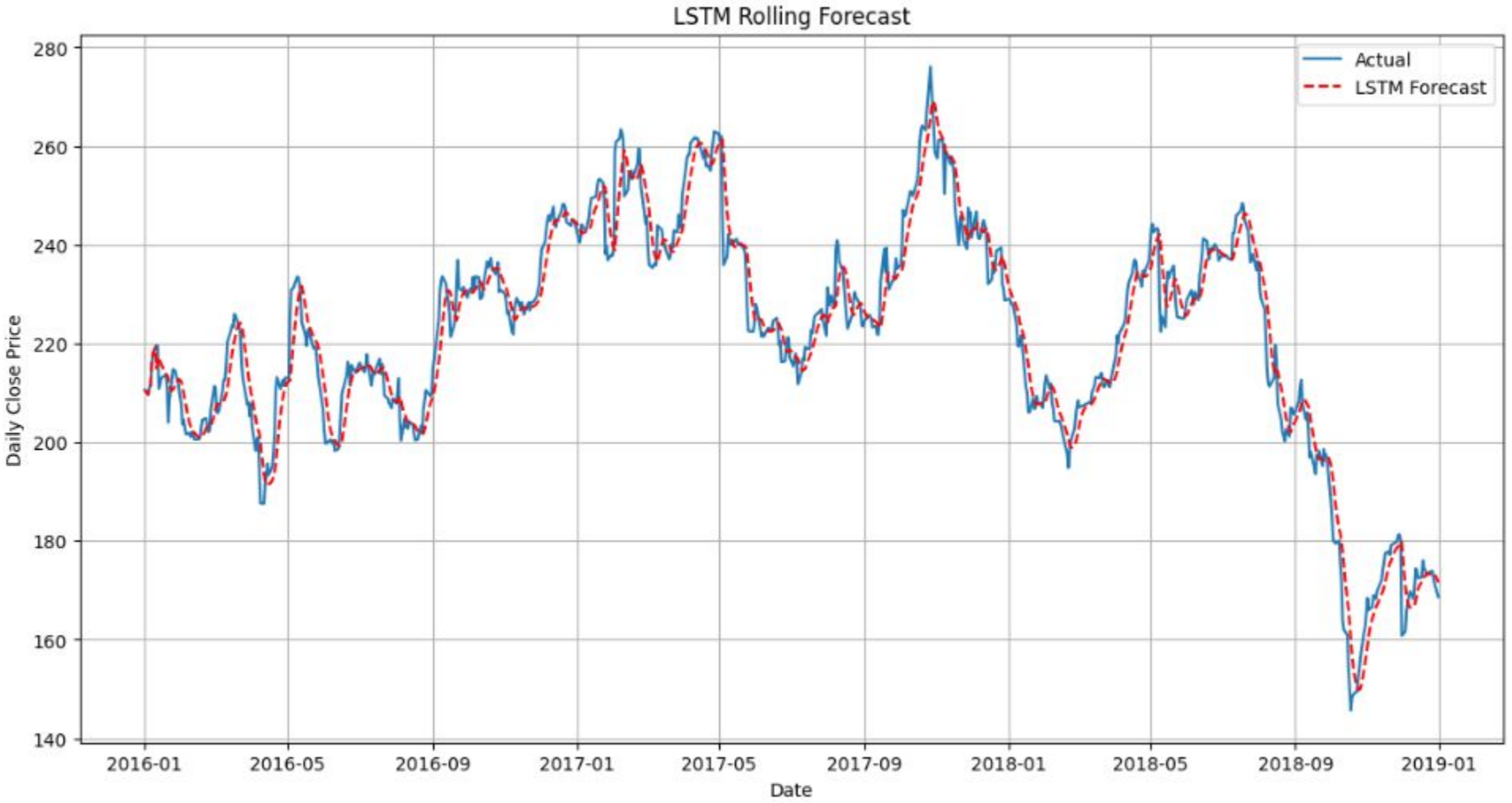


Stock: Agilent Technologies, Inc.

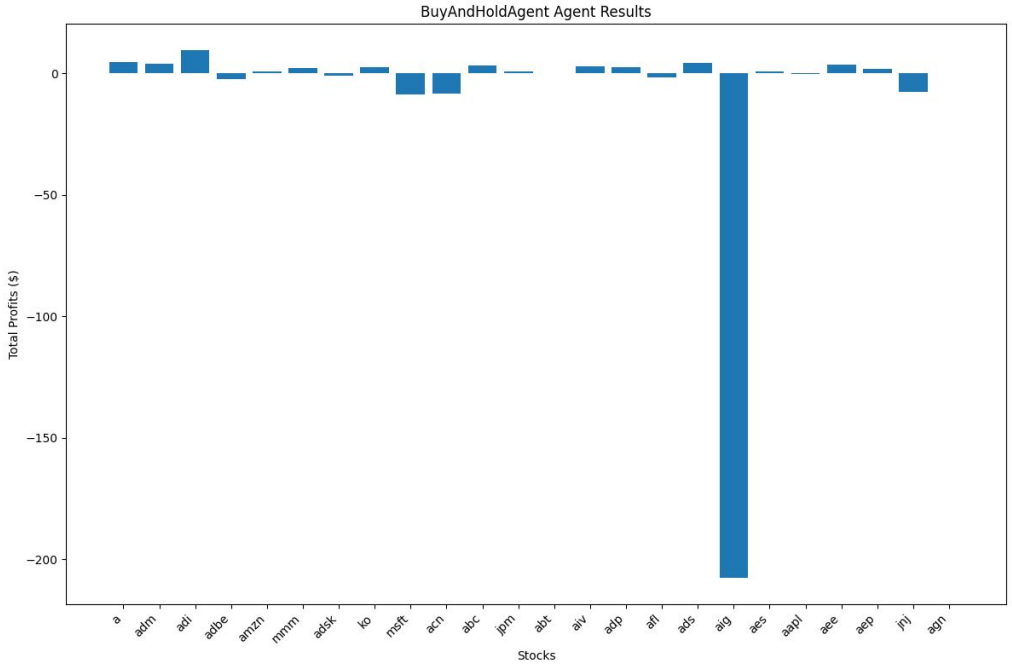
LSTM Initial Results

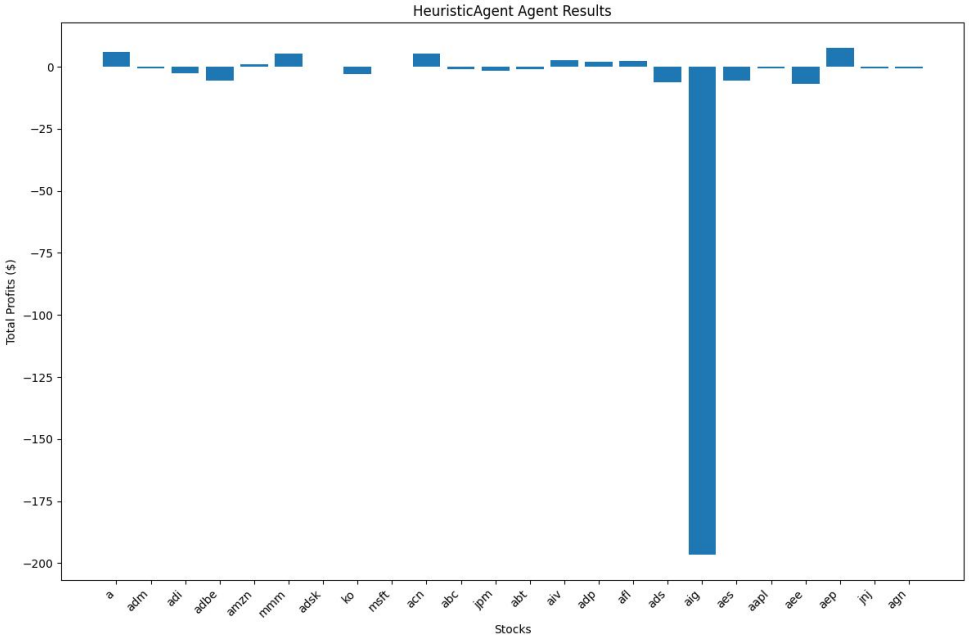


LSTM Results after Rolling Forecast

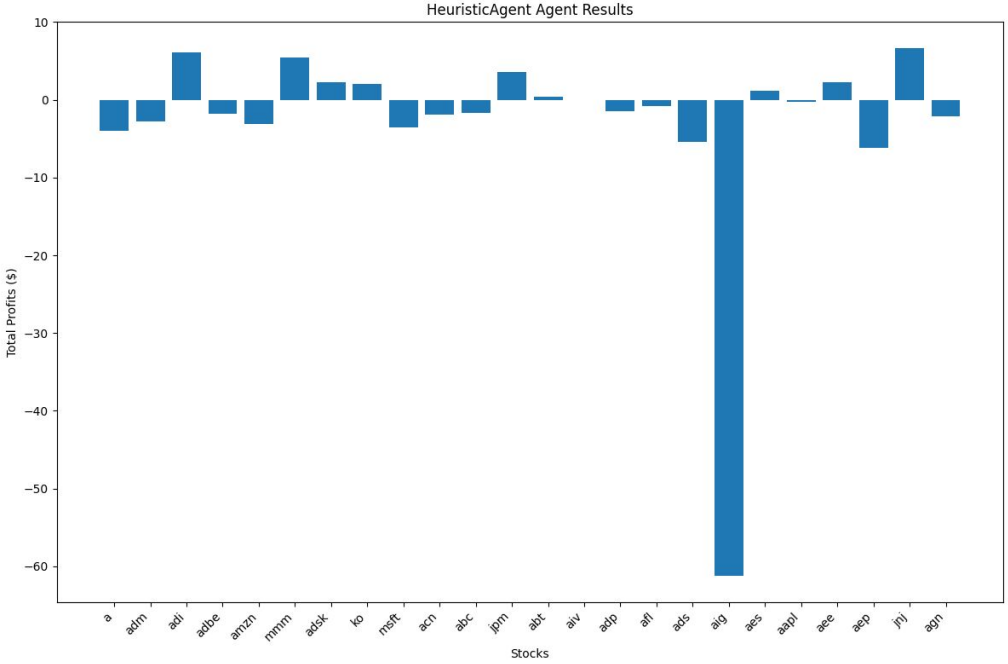


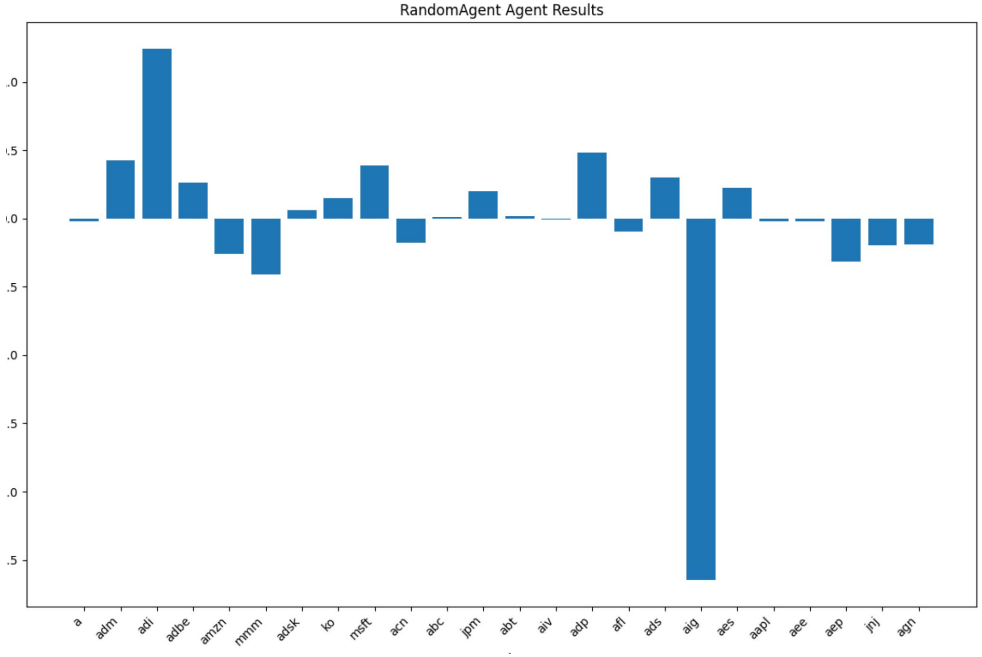
Stock: Adidas



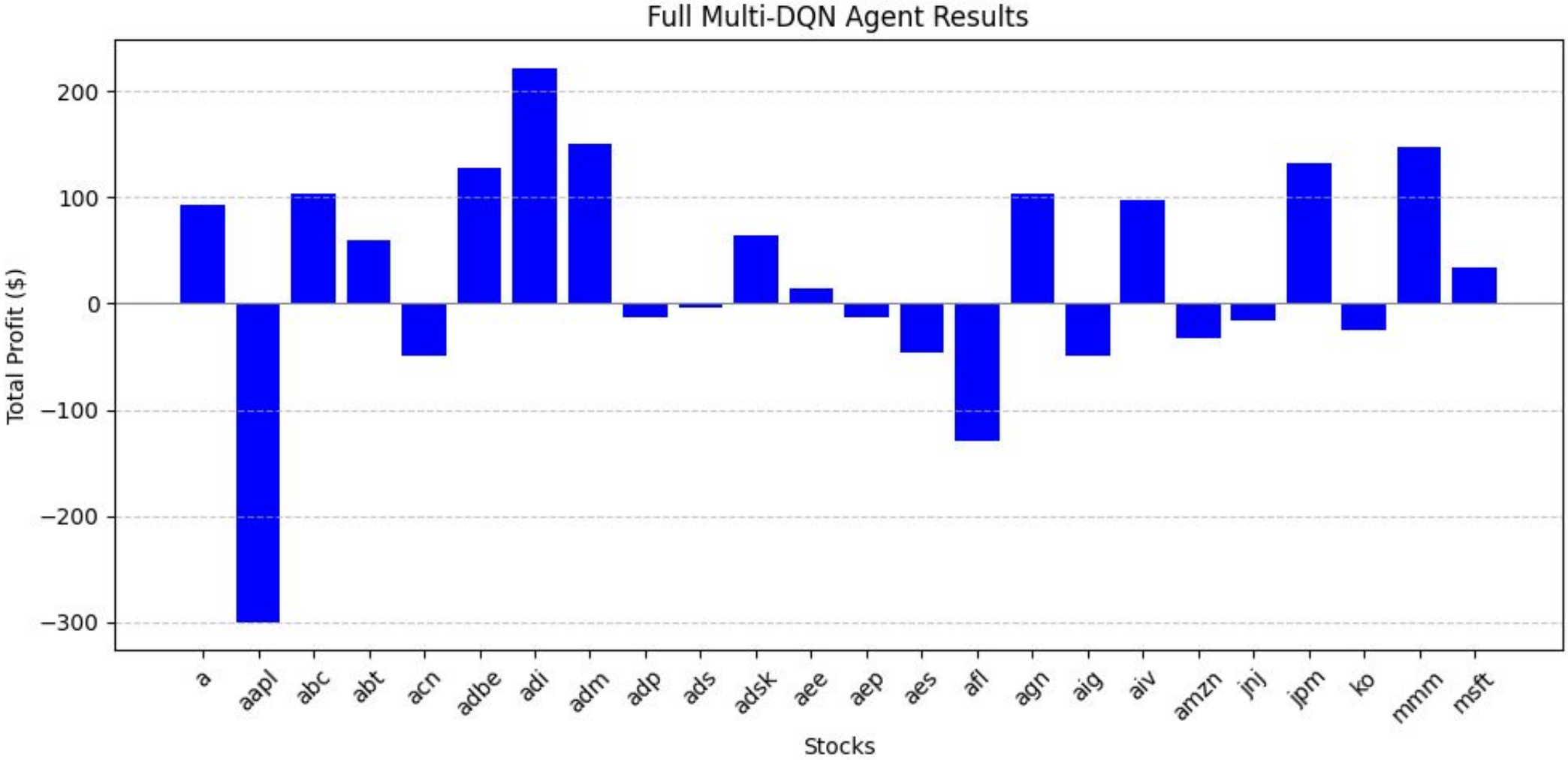


Heuristic 2





Heuristic 1


Full Multi-DQN Agent Results
Total Profit ($)
200
100
0
−100
−200
−300
a
aapl
abc
abt
acn
adbe
adi
adm
adp
ads
adsk
aee
aep
aes
afl
agn
aig
aiv
amzn
jnj
jpm
ko
mmm
msft
Stocks